PATENT ABSTRACTS OF JAPAN

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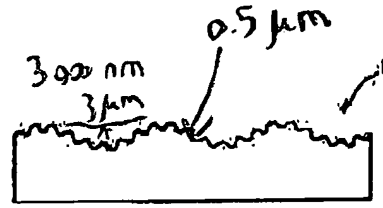
(54) SUBSTRATE FOR SOLAR CELL AND PRODUCTION THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a highly efficient cell without causing any crack in a thin film by roughening the surface of a substrate and forming irregularities on the surface at a lower average level difference thereby forming suitable irregularities at high speed without requiring any high temperature processing.
SOLUTION: Surface of a substrate 1 for solar cell is roughened by sand blasting and irregularities are on the surface at a lower average level difference. Since the light scattering effect is enhanced by the larger irregularities as compared with a conventional one and the optical path length in an amorphous silicon can be lengthened, short circuit current is increased and the efficiency of a solar cell can be enhanced. Average level difference of the irregularities is preferably is 3] m or above for obtaining a sufficient light scattering effect and the average level difference of the smaller irregularities is preferably is 0.5] m or below.



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(A) Relevance to claims

The document gives general background knowledge for the present invention.

(B) Translation of the relevant passage

[Claims]

[Claim 1]

A substrate for solar cells, being characterized in that a surface, for forming a solar cell, of the substrate is roughened so as to have irregularities (i), and a surface of each of the irregularities (i) further has small irregularities (ii), an average level difference of the irregularities (i) being larger than an average level difference of the irregularities (ii).

[Claim 2]

The substrate as defined in claim 1, wherein, the average level difference of the irregularities (i) is not less than 3μm, and the average level difference of the irregularities (ii) is not more than 0.5μm.

[Claim 3]

A manufacturing method of a substrate for solar

cells being characterized in that, a surface, for forming a solar cell, of the substrate is caused to have irregularities (i) by means of sandblasting using abrasive grains (a), and subsequently small irregularities (ii), an average level difference thereof being smaller than an average level difference of the irregularities (i), is formed on the irregularities (i) by means of sandblasting using abrasive grains (b) whose grain size is smaller than a grain size of the abrasive grains (a).

[Claim 4]

The manufacturing method as defined in claim 3, wherein, the surface is caused to have the irregularities (i), whose average level difference is not less than 3μm, by means of sandblasting using abrasive grains whose grain size is not less than 50μm, and subsequently, a surface of each of the irregularities (i) is caused to have the irregularities (ii), whose average level difference is not more than 0.5μm, by means of sandblasting using abrasive grains whose grain size is not more than 20μm.

[Problems to Be Solved by the Invention]

[0013]

That is to say, a substrate for solar cells in accordance with the present invention is arranged in such a manner that the surface, for forming a solar cell, of the substrate is formed so as to have irregularities whose

average level difference is preferably not less than 3μm, and the surface of each of the irregularities have small irregularities whose average level difference, preferably not more than 0.5μm, is smaller than the above-mentioned average level difference of the irregularities of the surface.

[0014]

Further, a manufacturing method of a substrate for solar cells in accordance with the present invention is arranged in such a manner that, the surface, for forming a solar cell, of the substrate is roughened to have irregularities by means of sandblasting using abrasive grains whose grain size is preferably not less than 50μm, and subsequently small irregularities, an average level difference thereof being smaller than an average level difference of the foregoing irregularities, are formed on the foregoing irregularities by means of sandblasting using abrasive grains whose grain size, preferably not more than 20μm, is smaller than the grain size of the foregoing abrasive grains.

[0015]

In the substrate for solar cells in accordance with the present invention, since the irregular surface of the substrate is caused to further have the small irregularities, the scattering effect by the small irregularities is

enhanced by the large irregularities so that the efficiency of a solar cell which is manufactured using the substrate for solar cells of the present invention is improved.

[Embodiments]

[0020]

This substrate 1 for solar cells is arranged in such a manner that, the surface of the substrate, which is for forming a solar cell and on which irregularities are formed, is caused to further have irregularities smaller than the foregoing irregularities.

[0021]

That is to say, as illustrated in a conventional example in Fig. 4, the light scattering effect of this substrate is improved so as to be better than the light scattering effect of a conventional substrate 1_0 which only has small irregularities. On this account, it is possible to elongate the light path length in an amorphous silicon film of an amorphous solar cell manufactured using the substrate 1 of the present invention, and hence a short-circuit current increases and consequently the efficiency of the solar cell improves.

[0022]

To obtain a sufficient light scattering effect, the average level difference of the large irregularities is preferably not less than 3μm, and the average level

difference of the small irregularities is preferably not more than 0.5μm, more preferably around 0.2μm.

[0023]

The small irregularities cause the light to scatter in the film, and since the difference of reflective indices is large at the interface between a transparent conductive film and a p-layer, the light greatly scatters. The large irregularities not only scatters the light but also causes reflected light to re-enter so as to return to a light absorbing layer. The large irregularities achieves an improved effect when the height thereof is equal to or sufficiently larger than a film which is 300-400nm thick, and as in Fig. 5, a short-circuit current significantly increases when the vertical interval of the large irregularities is not less than 3μm.

[0025]

A manufacturing method of the substrate for solar cells in accordance with the present invention is arranged in the following manner. As in Fig. 2(A), the surface of the substrate 1 is caused to have irregularities by means of sandblasting using abrasive grains 2. Subsequently, as in Fig. 2(B), sandblasting using abrasive grains 3 whose grain size is smaller than the abrasive grains 2 is performed so that, as in Fig. 2(C), irregularities whose average level difference D_2 is smaller than the average

level difference D_1 of the foregoing irregularities are formed on the surface.

[0035]

Thanks to this processing, as in Fig. 1, it is possible to obtain a relatively smooth substrate 1 for solar cells, on the surface of which irregularities whose average level difference is not more than 0.5μm is further formed on irregularities whose average level difference is around 3μm.

[0040]

Next, a transparent conductive film 4 which is, for instance, 1μm thick is formed on the substrate by sputtering. Alternatively, the transparent conductive film 4 may be formed by methods such as CVD and vapor deposition. Further, although the transparent conductive film 4 may be made of a material such as ITO, SnO_2, and ZnO, it is not preferable, in terms of the characteristics of solar cells, to make the film 4 sorely by ITO. On this account, when making the film 4 by ITO, the surface of the film 4 is necessarily coated with a material such as SnO_2 or ZnO which is several tens of nm thick.

[0046]

In this manner, elongating the light path length in the amorphous silicon film increases the short-circuit current of the thin-film solar cell 11. However, when the

irregularities are too rough, the top-surface electrode 4 tends to short-circuit with the bottom-surface electrode 9, since the thin-film solar cell 11 is only not more than 0.5μm thick. Thus, in this case, the irregularities have to be not more than 20% in haze rate.

[0047]

The substrate 1 of the present invention is arranged in such a manner that, as illustrated in Fig. 1, small irregularities are formed on large irregularities, and since the light scattering effect is caused not only by the small irregularities but also by the large irregularities, it is possible to increase the haze rate to be larger than the case of only forming small irregularities whose average level difference is not more than 0.5μm, for instance irregularities whose average level difference is 0.2μm. Further, the average level difference of the large irregularities is larger than the thickness of the solar cell 11 and not less than several micrometer, preferably not less than 3μm, so that the light scattering effect increases. For this reason, the top-surface electrode 4 hardly short-circuits with the bottom-surface electrode 9. This is because the amorphous silicon film is formed along the large irregularities so that the distance between the top-surface electrode 4 and the bottom-surface electrode 9 does not reduces.

[0048]

Further, in the case of a conventional method of forming irregularities using transparent electrodes made of a material such as SnO_2, slight variation of the condition of film development results in non-uniformity of irregularities. In contrast, the present invention for directly forming irregularities on a substrate by means of sandblasting makes it possible to easily improve the precision of manufacturing the irregularities.

[0054]

[Effects of the Invention]

As described above, according to the present invention, small irregularities are further formed on the irregular surface of a substrate so that the large irregularities on the surface enhances the light scattering effect caused by the small irregularities. On this account, since the light path length in an amorphous silicon film of a solar cell can be elongated, a short-circuit current increases and hence the efficiency of the solar cell can be improved.

[Fig. 5]

(On the Left)

STANDIZED SHORT-CIRCUIT CURRENT

(On the Bottom)

VERTICAL INTERVAL BETWEEN CRESTS AND TROUGHS OF LARGE IRREGULARITIES [μm]

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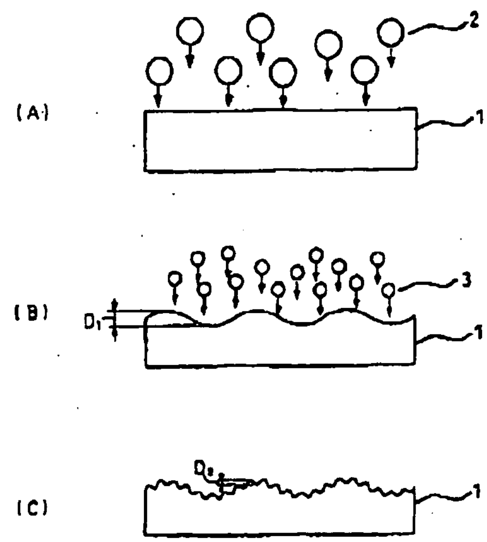
(54)【発明の名称】 太陽電池用基板およびその製造方法

(57)【要約】
【課題】非晶質シリコン太陽電池に好適な凹凸を、高温処理を用いることなく、高速で形成できるとともに、薄膜に亀裂を生じさせることなく、効率の高い太陽電池を提供できるようにすることを目的とする。
【解決手段】 太陽電池が形成される基板1の表面を、砥粒2を用いてサンドブラスト処理を行って平均段差3μ以上の凹凸状に形成した後に、前記砥粒2よりも粒径の小さな砥粒3を用いてサンドブラスト処理を行って平均段差0.5μm以下の凹凸状に形成するものである。



1

【特許請求の範囲】

【請求項1】　太陽電池を形成する基板の表面が、凹凸状に形成されるとともに、該凹凸状の表面が、該凹凸状の平均段差よりも小さな平均段差の凹凸状に形成されることを特徴とする太陽電池用基板。

【請求項2】　太陽電池を形成する基板の表面が、平均段差が3μm以上の凹凸状に形成されるとともに、該凹凸状の表面が、平均段差が0.5μm以下の凹凸状に形成される請求項1記載の太陽電池用基板。

【請求項3】　太陽電池を形成する基板の表面を、砥粒を用いてサンドブラスト処理を行って凹凸状に形成した後に、前記砥粒よりも粒径の小さな砥粒を用いてサンドブラスト処理を行って前記凹凸状の平均段差よりも小さな平均段差の凹凸状に形成することを特徴とする太陽電池用基板の製造方法。

【請求項4】　太陽電池を形成する基板の表面を、粒径50μm以上の砥粒を用いてサンドブラスト処理を行って平均段差が3μm以上の凹凸状に形成した後に、該凹凸状の表面を、粒径20μm以下の砥粒を用いてサンドブラスト処理を行って平均段差が0.5μm以下の凹凸状に形成する請求項3記載の太陽電池用基板の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、太陽電池用基板およびその製造方法に関する。

【0002】

【従来の技術】太陽電池、例えば非晶質シリコン太陽電池は、100℃～200℃程度の比較的低温で形成できるために、様々な基板を用いることが可能であり、通常、ガラス基板やステンレス基板がよく用いられる。非晶質シリコン太陽電池は、効率が最大となる時の光吸収層である非晶質シリコン層の膜厚が、例えば500nm程度と薄いために、効率向上には、この膜厚で光の吸収量を増加させることが重要となる。

【0003】このため、ガラス基板上に凹凸のある透明電極を形成したり、ステンレス基板上に凹凸のある表面を形成したりすることにより、非晶質シリコン膜中での光の光路長を増加させることが従来行われてきた。

【0004】例えば、特開昭58－57756号公報、特開昭59－159574号公報等には、基板上に凹凸のある透明電極を形成する方法が記載されており、また、特開平7－122764号公報には、ガラス基板に直接凹凸を形成する方法が記載されている。

【0005】

【発明が解決しようとする課題】例えば、ガラス基板上に凹凸のある透明電極を形成する一般的な方法としては、常圧CVD法により透明電極としてSnO_2を形成する方法があげられ、この方法は、簡便な方法ではあるが、その形成温度が500℃程度の高温を必要とすることから、強化ガラス上に形成できず、通常の強化していないガラスを用いなければならないという問題点があった。これは強化ガラスが300℃以上の高温では強化が鈍ってしまうからである。

2

【0006】太陽電池モジュールは、雹などの衝撃に耐える必要があるため、表面に強化ガラスが必要であり、したがって、常圧CVD法によって凹凸のある透明電極を形成する従来の方法では、通常の強化していないガラス基板を用いて形成し、さらに、これに強化ガラスを貼り合わせる必要があり、太陽電池モジュールは、強化ガラスと通常のガラスの二重構造となってしまい、製造コストが増加するという問題点があった。

【0007】さらに光を十分散乱させるためには、透明電極の膜厚を1μm程度形成する必要があり、形成に時間を要するとともに、材料費がかさむという問題点があった。

【0008】また、ガラス基板に、直接凹凸を形成する方法では、透明電極で形成するような微小な凹凸を形成する方法がなく、例えば、上述の特開平7－12274号公報においては、ガラス基板に対してサンドブラスト法で凹凸を形成しているが、1回のサンドブラスト処理では凹凸の突起が鋭くなるために、素子製作の際に薄膜に亀裂が生じるという問題点があった。

【0009】一方、ステンレス基板に、Agを蒸着やスパッタリングによって凹凸状に形成する方法では、300℃以上の高温が必要となるために、基板の昇温、降温に時間がかかったり、基板の反りといった問題があった。

【0010】さらにステンレス基板等の金属基板の場合には表面に傷があるために、歩留まり向上のために研磨処理が必要であり、コストアップの要因となっていた。

【0011】本発明は、上述のような技術的課題に鑑みて為されたものであって、非晶質シリコン太陽電池に好適な凹凸を、高温処理を用いることなく、高速で形成できるとともに、薄膜に亀裂を生じさせることなく、効率の高い太陽電池を提供できるようにすることを目的とする。

【0012】

【課題を解決するための手段】本発明では、上述の目的を達成するために、次のように構成している。

【0013】すなわち、本発明の太陽電池用基板は、太陽電池を形成する基板の表面が、凹凸状、好ましくは、平均段差が3μm以上の凹凸状に形成されるとともに、該凹凸状の表面が、該凹凸状の平均段差よりも小さな平均段差、好ましくは、0.5μm以下の平均段差の凹凸状に形成されるものである。

【0014】また、本発明の太陽電池用基板の製造方法は、太陽電池を形成する基板の表面を、砥粒、好ましくは、粒径50μm以上の砥粒を用いてサンドブラスト処理を行って凹凸状に形成した後に、前記砥粒よりも粒径

の小さな砥粒、好ましくは、粒径20μm以下の砥粒を用いてサンドブラスト処理を行って前記凹凸状の平均段差よりも小さな平均段差の凹凸状に形成するものである。

【0015】本発明の太陽電池用基板によれば、凹凸状の基板の表面に、それよりも小さな段差の凹凸を形成するので、小さな段差の凹凸による光の散乱効果に加えて、大きな段差の凹凸によって光の散乱効果が一層増大することになり、本発明の太陽電池用基板を用いて製作された太陽電池の効率が向上することになる。

【0016】本発明の太陽電池用基板の製造方法によれば、サンドブラスト法によって基板に直接凹凸を形成するので、凹凸のある透明電極を形成する従来の方法に比べて、凹凸の制御が容易であるとともに、室温での処理が可能となり、強化ガラス上に凹凸を形成できることになる。

【0017】また、1回目のサンドブラスト処理の後に、粒径の小さな砥粒を用いて再びサンドブラスト処理を行うので、素子製作の際に薄膜に亀裂が生じるといったことがない。

【0018】

【発明の実施の形態】以下、図面によって本発明の実施の形態について、詳細に説明する。

【0019】図1は、本発明の太陽電池用基板の概略断面図である。

【0020】この太陽電池用基板1は、サンドブラスト法によって、太陽電池を形成する基板の表面が、凹凸状に形成されるとともに、さらに、その凹凸状の表面が、その平均段差よりも小さな平均段差の凹凸状に形成されるものである。

【0021】すなわち、本発明の太陽電池用基板1は、大きな凹凸の基板表面に、それよりも小さな凹凸が形成されてなるものであって、図4の従来例のように、小さな凹凸のみが形成された従来の基板1_0に比べて、大きな凹凸による光の散乱効果が増大することになり、これによって、本発明の太陽電池用基板1を用いて製作された非晶質シリコン太陽電池の非晶質シリコン膜中での光の光路長を増加させることができるので、短絡電流が増加して太陽電池の効率の向上を図ることができる。

【0022】十分な光の散乱効果を得るためには、大きな凹凸状の平均段差は、3μm以上であるのが好ましく、また、小さな凹凸状の平均段差は、0.5μm以下、望ましくは、0.2μm程度であるのが好ましい。

【0023】小さな凹凸は、膜中で光を散乱させる効果があり、透明導電膜とp層との界面では、屈折率の差が大きいために、光を大きく散乱させるものである。また、大きな凹凸は、光の散乱効果もあるが、さらに、反射光を再入射させて光吸収層に戻す効果がある。この大きな凹凸は、その段差が、300～400nmの膜厚と同程度かそれよりも十分大きいときに、その効果が大きく、図5に示されるように、大きな凹凸の段差（高低差）が、3μm以上で短絡電流の大きな増加が認められる。

【0024】図2は、図1の太陽電池用基板の製造方法を示す断面図である。

【0025】本発明の太陽電池用基板の製造方法は、基板1の表面を、同図（A）に示されるように、砥粒2を用いてサンドブラスト処理を行って凹凸状に形成した後に、同図（B）に示されるように、前記砥粒2よりも粒径の小さな砥粒3を用いてサンドブラスト処理を行い、同図（C）に示されるように、前記凹凸状の平均段差D_1よりも小さな平均段差D_2の凹凸状に形成するものである。

【0026】1回目のサンドブラスト処理の砥粒2の粒径は、上述の平均段差30μmの凹凸状に形成するためには、50μm以上であるのが好ましく、2回目のサンドブラスト処理の砥粒3の粒径は、平均段差0.5μm以下の凹凸状に形成するためには、20μm以下であるのが好ましい。

【0027】本発明の基板1としては、サンドブラスト法によって凹凸を形成できる程度の硬い基板であればよく、例えばガラス、金属、セラミックス、プラスチックス、カーボンのような材料からなる基板を用いることができる。

【0028】また、本発明の砥粒2、3の種類としては、アルミナ、ホワイトアルミナ、カーボランダム等を用いることができる。

【0029】以下、本発明の実施の形態を、ガラス基板に適用して具体的に説明する。

【0030】この実施の形態の太陽電池用基板の製造方法では、先ず、ガラス基板を加工用の台にセットして噴射ノズルから砥粒を吹き付けながら基板加工用の台を移動させる。

【0031】このとき用いる砥粒の種類は、上述のようにアルミナ、ホワイトアルミナ、カーボランダム等であり、砥粒の番手としては、＃1000以下、例えば＃800を用いる。すなわち、砥粒としては、その粒径が25.4μm以上、例えば、31.75μmの砥粒を用いる。また、ノズル径は通常φ7mm程度であり、処理する基板の大きさや処理速度に応じてノズルの数を設定する。

【0032】次に、噴射圧力として、例えば3～4kg／cm^2程度、噴射距離として、例えば8cm程度に設定する。噴射角度は、例えば90度、加工用の台の速度は、例えば250mm／min、噴射量は、例えば50g／min程度に設定する。通常のソーダガラスの場合には、このようなパラメータで平均段差が3μm程度の凹凸を得ることができる。

【0033】しかし、このままではガラス基板表面が、ガラスが欠けたような凹凸で覆われており、尖った部分

が散見される。このまま太陽電池用基板として用いると太陽電池が短絡してしまうために、表面をもう一度サンドブラスト処理する必要がある。　そこで、砥粒の番手としては、＃２０００以上、望ましくは＃３０００を用いて同じ基板をもう一度サンドブラスト処理を行う。すなわち、砥粒としては、その粒径が１２．７μｍ以下、例えば、８．４７μｍの砥粒を用いる。また、ノズル径は、通常φ７ｍｍ程度であり、処理する基板の大きさや処理速度に応じてノズルの数を設定する。

【００３４】次に、１回目のサンドブラスト処理と同様に、噴射圧力として３～４ｋｇ／ｃｍ²程度、噴射距離としては８ｃｍ程度に設定する。噴射角度は、９０度、加工用の台の速度は２５ｍｍ／ｍｉｎ、噴射量は５０ｇ／ｍｉｎ程度に設定する。

【００３５】このような処理を行うことにより、上述の図１に示されるように、平均段差が３μｍ程度の凹凸状の表面に、さらに平均段差が０．５μｍ以下の凹凸が形成された比較的滑らかな太陽電池用基板１を得ることができる。

【００３６】なお、本発明の他の実施の形態として、砥粒に代えて砥粒を分散させた液を噴射するようにしてもよい。

【００３７】次に、以上のようにして製造した太陽電池用基板１を用いて図３に示される薄膜太陽電池１１を製造する方法を説明する。

【００３８】先ず、以上のようにして製造した、例えば、厚さ１ｍｍの太陽電池用基板１の洗浄を行う。これはサンドブラストで加工した後にアルミナ等の粉が基板表面に残っているので、それを除くためである。

【００３９】洗浄方法としては、例えば純水による超音＊波洗浄を行う。洗浄方法としては特に限定されないが、サンドブラスト処理以前の基板表面に油汚れが無いような基板であれば簡単な洗浄でよい。

【００４０】次に、基板上にスパッタリング法により透明導電膜４を、例えば厚さ１μｍに形成する。透明導電膜４を形成する方法は、ＣＶＤ法や蒸着法を用いてもよい。また、透明導電膜４はＩＴＯ、SnO_2、ＺｎＯなどを用いることができるが、ＩＴＯのみを用いることは太陽電池の特性上好ましくないので、これを用いる場合には、SnO_2、ＺｎＯなどで表面を薄く数１０ｎｍコーティングしておく必要がある。

【００４１】透明導電膜４を形成する条件は、通常の条件でよく、従来例のように、凹凸を形成するための特殊な形成条件、例えば、５００°Ｃの高温にするといった必要がなく、凹凸および面抵抗の再現性が改善される。透明導電膜４の形成後、プラズマＣＶＤ装置でアモルファスシリコンカーボンｐ層５、ｂ層（アモルファスシリコンカーボン組成変化層）６、アモルファスシリコンｉ層７、アモルファスシリコンｎ層８を順次形成する。各層５，６，７，８の厚さは、例えば、それぞれ、１０ｎｍ、１０ｎｍ、３００ｎｍ、３０ｎｍである。

【００４２】なお、ｐ層５は凹凸の大きさにより最適な膜厚が存在し、例えばヘイズ率（ガラスの透過光のうち光が散乱された割合）１５程度では１５ｎｍ程度でもよいが、ヘイズ率３０程度にすると１８～２０ｎｍ程度の膜厚に設定するのが好ましい。

【００４３】なお各層の形成条件の一例を表に示す。

【００４４】

【表１】

	基板温度（℃）	パワー（W/cm²）	圧力（Torr）	ガス流量（sccm）
ｐ層	170	0.5	0.25	SiH_4:1, H_2:100, B_2H_6:0.01
ｂ層	170	0.05	0.25	SiH_4:32, H_2:30, CH_4:32～0
ｉ層	170	0.1	0.12	SiH_4:42, H_2:14
ｎ層	170	0.5	0.25	SiH_4:1, H_2:100, PH_3:0.01

【００４５】次に、裏面電極９としてスパッタリングによりＺｎＯを、例えば５０ｎｍ形成する。最後に裏面金属反射電極１０としてＡｇを、例えば５００ｎｍ形成する。このようにして形成した太陽電池１１の特性としては、短絡電流Ｉｓｃ：１９．８ｍA／ｃｍ²、開放電圧Ｖｏｃ：０．８７Ｖ、曲線因子ＦＦ：０．７３、効率η：１２．６％が得られた。この特性は、従来の透明電極を用いて凹凸形成を行ったセル特性と比較しても遜色なく、サンドブラスト法による一回処理の場合と比較して短絡電流に関しては大きい値となっている。

【００４６】このようにして、非晶質シリコン膜中での光の光路長を増加させることにより、薄膜太陽電池１１の短絡電流が向上するが、あまり凹凸を大きくすると薄膜太陽電池１１の膜厚が、例えば０．５μｍ以下と薄いために、表面電極４と裏面電極９とが短絡しやすくなる。そのため、このような膜厚のもとでは、ヘイズ率で２０％程度が凹凸の限界である。

【００４７】本発明の基板１では、図１に示すように大きな凹凸の上に微小な凹凸が形成されており、光の散乱効果は、上述のように大きな凹凸によっても生じるので、０．５μｍ以下の微小な凹凸のみ、例えば、平均段差０．２μｍの微小な凹凸のみを形成する場合よりもヘイズ率を大きくできる。さらに、大きな凹凸は、太陽電池１１の膜厚よりも大きく、数ミクロン以上、好ましくは、平均段差３μｍ以上の凹凸であって光の散乱を増加させるため、表面電極４と裏面電極９が短絡しにくい。これは、非晶質シリコン膜自体が大きな凹凸に沿って形成されるために、表面電極４と裏面電極９との間隔が縮

まることがないためである。

【0048】また、SnO_2等の透明電極によって凹凸を形成する従来の方法では、膜成長条件を制御するために、わずかな条件設定の変化により凹凸のばらつきが生じやすいのに対して、サンドブラスト法を用いて基板に直接凹凸を形成する本発明では、微妙な凹凸を制御するのが容易である。

【0049】また、サンドブラスト法では、室温で凹凸が形成できるので、従来の常圧ＣＶＤ法のような５００℃程度の高温を必要とせず、強化ガラス上に凹凸を形成することができ、これによって、従来例のように通常の強化していないガラスと強化ガラスとを貼り合わせる必要がなくなり、その分太陽電池モジュールのコストを低減することができる。

【0050】さらに、透明電極も従来例のように、凹凸形状を大きくするために厚くする必要がなく、例えば、２００ｎｍ程度、すなわち従来の１／４～１／５の膜厚でよく、その分材料費が低減できるので低コスト化を図ることができる。

【0051】また、ステンレス基板等の金属基板を用いる場合にも、本発明のサンドブラスト法により室温で凹凸を形成できるので、基板の昇温、降温に時間がかからず、基板の反りといった問題もなくなる。さらに、金属基板表面にある傷が歩留まりを低下させるために、通常、金属基板は研磨処理する必要があるが、表面をサンドブラスト処理することにより基板全体の傷を平滑化でき、同時に凹凸形成ができ非常に効率的である。

【0052】このような本発明の太陽電池用基板を用いることにより、従来よりも低コストで効率も同等以上の太陽電池を形成することが可能になる。

【0053】上述の実施の形態では、ガラス基板に適用して説明したけれども、本発明の他の実施の形態として、ステンレス基板等の他の材料の基板を用いてもよいのは勿論である。＊

＊【0054】

【発明の効果】以上のように本発明によれば、凹凸状の基板の表面に、それよりも小さな段差の凹凸を形成するので、小さな段差の凹凸による光の散乱効果に加えて、大きな段差の凹凸によって光の散乱効果が一層増大することになり、これによって、太陽電池の非晶質シリコン膜中での光の光路長を増加させることができるので、短絡電流が増加して太陽電池の効率の向上を図ることができる。

【0055】また、本発明によれば、サンドブラスト法によって基板に直接凹凸を形成するので、凹凸のある透明電極を形成する従来の方法のように、高温での処理が不要となり、強化ガラス上に凹凸を形成できることになり、また、金属基板を用いた場合に、基板の反りの問題も解消することになる。

【0056】また、１回目のサンドブラスト処理の後に、粒径の小さな砥粒を用いて再びサンドブラスト処理を行うので、素子製作の際に薄膜に亀裂が生じるといったことがない。

【図面の簡単な説明】

【図１】本発明の一つの実施の形態に係る太陽電池用基板の概略断面図である。

【図２】本発明の一つの実施の形態に係る太陽電池用基板の製造方法を示す概略断面図である。

【図３】本発明の太陽電池用基板を用いて製作された太陽電池の概略断面図である。

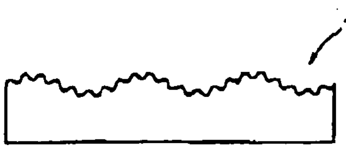
【図４】従来例の太陽電池用基板の概略断面図である。

【図５】大きな凹凸の段差と短絡電流との関係を示す特性図である。

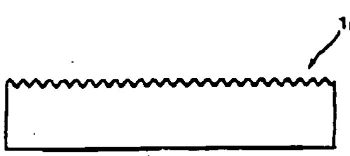
【符号の説明】

１，１，	太陽電池用基板
２，３	砥粒
４	透明導電膜
１１	太陽電池

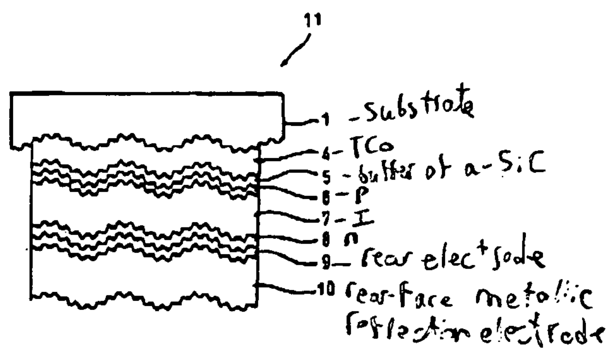
【図１】



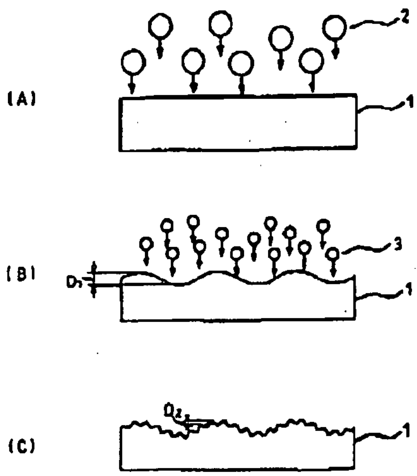
【図４】



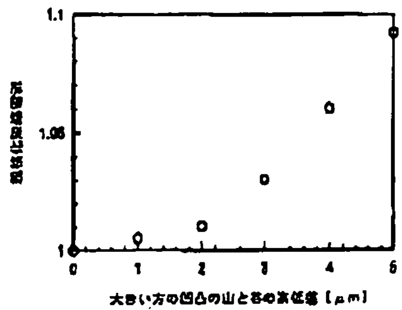
【図３】



【図2】



【図5】



* NOTICES *

JP 10-70294

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the substrate for solar batteries, and its manufacture method.
[0002]
[Description of the Prior Art] A solar battery, for example, an amorphous silicon solar cell, can use substrates various 100 degrees C - about 200 degrees C since it can form at low temperature comparatively, and a glass substrate and a stainless steel substrate are usually used well. It becomes important for it, since an amorphous silicon solar cell has the thickness of the amorphous silicon layer which is an optical-absorption layer in case efficiency serves as the maximum as thin as about 500nm to make the amount of absorption of light increase to improvement in efficiency by this thickness.
[0003] For this reason, making the optical path length of the light in the inside of an amorphous silicon film increase has been conventionally performed by forming an irregular transparent electrode on a glass substrate, or forming an irregular front face on a stainless steel substrate.
[0004] For example, the method which the method of forming an irregular transparent electrode on a substrate is indicated by JP,58-57756,A and JP,59-159574,A, and forms direct irregularity in JP,7-122764,A at a glass substrate is indicated.
[0005]
[Problem(s) to be Solved by the Invention] For example, as common practice which forms an irregular transparent electrode on a glass substrate, the method of forming SnO2 as a transparent electrode by ordinary-pressure CVD was raised, and although it was a simple method, since the formation temperature needed the elevated temperature which is about 500 degrees C, this method could not be formed on tempered glass, but had the trouble that the glass which has not strengthened usual had to be used. This is because strengthening of tempered glass becomes blunt at the elevated temperature of 300 degrees C or more.
[0006] By the conventional method of forming an irregular transparent electrode by ordinary-pressure CVD, further, since a solar cell module needed to bear shocks, such as hail, it needed tempered glass for the front face, therefore it needs to stick tempered glass on this, was formed using the glass substrate which has not strengthened usual and had [the solar cell module became the dual structure of tempered glass and usual glass, and] the trouble that a manufacturing cost increased.
[0007] In order to scatter light enough furthermore, while about 1 micrometer of thickness of a transparent electrode needed to be formed and formation took time, there was a trouble that the cost of materials increased.
[0008] Moreover, by one sandblasting processing, although there is no method of forming minute irregularity which is formed by the transparent electrode by the method of forming direct irregularity in a glass substrate, for example, irregularity was formed in it by the sandblasting method to the glass substrate in above-mentioned JP,7-12274,A, since a concavo-convex salient became sharp, the trouble that a crack arose was in the thin film on the occasion of element manufacture.
[0009] Since the elevated temperature of 300 degrees C or more was needed, on the other hand by the method of forming Ag in a stainless steel substrate in the shape of irregularity by vacuum evaporationo or sputtering, the temperature up of a substrate took, the temperature fall took time, and there was a problem of the curvature of a substrate.
[0010] Furthermore, since a blemish was shown in a front face in the case of metal substrates, such as a stainless steel substrate, polish processing is required because of the improvement in the yield, and it had become the factor of a cost rise.
[0011] In view of the above technical technical problems, it succeeds in this invention, and it aims at enabling it to offer the high solar battery of efficiency, without making a thin film produce a crack, while being able to form the suitable irregularity for an amorphous silicon solar cell at high speed, without using high temperature processing.
[0012]
front face Irreg
[Means for Solving the Problem] In order to attain the above-mentioned purpose, it constitutes from this invention as follows.
[0013] namely, the front face of a substrate in which the substrate for solar batteries of this invention forms a solar battery -- the shape of irregularity -- preferably, while an average level difference is formed 3 micrometers or more in the shape of irregularity, the front faces of the shape of this irregularity are an average level difference smaller than the average level difference of the shape of this irregularity, and the thing formed with an average level difference of 0.5 micrometers or less in the shape of irregularity
[0014] Moreover, about the front face of the substrate which forms a solar battery, the manufacture methods of the substrate for solar batteries of this invention are an abrasive grain with a particle size smaller than the aforementioned abrasive grain, and a thing which performs sandblasting processing using an abrasive grain with a particle size of 20 micrometers or less, and is preferably formed in the shape of [of an average level difference smaller than the average level difference of the shape of aforementioned irregularity] irregularity, after performing sandblasting processing using an abrasive grain with a particle size of 50 micrometers or more and forming in the shape of irregularity preferably, an abrasive grain
[0015] According to the substrate for solar batteries of this invention, since the irregularity of a level difference smaller than it is formed in the front face of an irregularity-like substrate, in addition to the scattering effect of the light by the irregularity of a small level difference, the scattering effect of light will increase further with the irregularity of a big level difference, and the efficiency of the solar battery manufactured using the substrate for solar batteries of this invention will improve.
[0016] Since direct irregularity is formed in a substrate by the sandblasting method, while concavo-convex control is easy compared with the

conventional method of forming an irregular transparent electrode according to the manufacture method of the substrate for solar batteries of this invention, processing at a room temperature will be attained and irregularity can be formed on tempered glass.
[0017] Moreover, since an abrasive grain with a small particle size is used and sandblasting processing is again performed after the 1st sandblasting processing, it has not been told to a thin film in the case of element manufacture that a crack arises.
[0018]
[Embodiments of the Invention] Hereafter, the form of operation of this invention with a drawing is explained in detail.
[0019] Drawing 1 is the outline cross section of the substrate for solar batteries of this invention.
[0020] While the front face of a substrate in which this substrate 1 for solar batteries forms a solar battery by the sandblasting method is formed in the shape of irregularity, the front face of the shape of the irregularity is further formed in the shape of [of an average level difference smaller than the average level difference] irregularity.
[0021] The substrate 1 for solar batteries of this invention is a thing which comes to form irregularity smaller than it in a concavo-convex big substrate front face. namely, like the conventional example of drawing 4 Compared with the conventional substrate 10 in which only small irregularity was formed, the scattering effect of the light by big irregularity will increase. by this Since the optical path length of the light in the inside of the amorphous silicon film of the amorphous silicon solar cell manufactured using the substrate 1 for solar batteries of this invention can be made to increase, a short-circuit current increases and improvement in the efficiency of a solar battery can be aimed at.
[0022] In order to obtain the scattering effect of sufficient light, as for the small irregularity-like average level difference with desirable [a big irregularity-like average level difference] and it being 3 micrometers or more, it is desirable desirably that it is about 0.2 micrometers 0.5 micrometers or less.
[0023] the effect of scattering light in a film has small irregularity, and in the interface of a transparent electric conduction film and p layers, since the difference of a refractive index is large, light is scattered greatly -- it is a thing Moreover, although the scattering effect of light also has big irregularity, there is an effect which is made to carry out re-incidence of the reflected light, and is further returned to an optical-absorption layer. When sufficiently larger than it, the level difference of this big irregularity is of the same grade as 300-400nm thickness, or the effect is large, and as shown in drawing 5 , the level difference (difference of elevation) of big irregularity is accepted for the big increase in a short-circuit current by 3 micrometers or more.
[0024] Drawing 2 is the cross section showing the manufacture method of the substrate for solar batteries of drawing 1..
[0025] As shown in this drawing (A), the manufacture method of the substrate for solar batteries of this invention the front face of a substrate 1 After performing sandblasting processing using an abrasive grain 2 and forming in the shape of irregularity, as shown in this drawing (B) Sandblasting processing is performed using the abrasive grain 3 with a particle size smaller than the aforementioned abrasive grain 2, and as shown in this drawing (C), it forms in the shape of [of the average level difference D2 smaller than the average level difference D1 of the shape of aforementioned irregularity] irregularity.
[0026] As for the particle size of the abrasive grain 2 of the 1st sandblasting processing, it is desirable that it is 50 micrometers or more in order to form with an above-mentioned average level difference of 30 micrometers in the shape of irregularity, and in order to form with an average level difference of 0.5 micrometers or less in the shape of irregularity, as for the particle size of the abrasive grain 3 of the sandblasting processing which is the 2nd time, it is desirable that it is 20 micrometers or less.
[0027] The substrate which consists of glass, a metal, ceramics, plastics, and material like carbon can be used that what is necessary is just the stiff substrate of the grade which can form irregularity by the sandblasting method as a substrate 1 of this invention.
[0028] Moreover, an alumina, a white alumina, a Carborundum, etc. can be used as a kind of abrasive grains 2 and 3 of this invention.
[0029] Hereafter, with the application of the form of operation of this invention, it explains to a glass substrate concretely.
[0030] The base for substrate processing is moved by the manufacture method of the substrate for solar batteries of the form this operation, setting a glass substrate to the base for processing, and spraying an abrasive grain from an injection nozzle first.
[0031] The kinds of abrasive grain used at this time are an alumina, a white alumina, a Carborundum, etc. as mentioned above, and less than #1000], #800 [for example,], is used for them as the yarn count of an abrasive grain. That is, as an abrasive grain, the abrasive grain the particle size of whose is 25.4 micrometers or more, for example, 31.75 micrometers, is used. Moreover, the diameter of a nozzle is usually about phi7mm, and sets up the number of nozzles according to the size and processing speed of a substrate to process.
[0032] Next, it is set as about 8cm as about two 3 - 4 kg/cm and an injection distance as an injection pressure. The speed of the base for processing is set for example, as 250 mm/min 90 degrees, and the degree of spray angle sets the injection quantity as about 50 g/min. In the case of the usual soda glass, the irregularity whose average level difference is about 3 micrometers can be obtained with such a parameter.
[0033] However, with this, the glass-substrate front face is being worn with irregularity which glass lacked, and the sharp portion appears here and there. If it uses as a substrate for solar batteries as it is, in order for a solar battery to connect too hastily, it is necessary to already carry out the degree sandblasting processing of the front face of -. then -- as the yarn count of an abrasive grain -- # -- 2000 or more, the same substrate is also desirably obtained using #3000 and the degree sandblasting processing of - is performed That is, as an abrasive grain, the abrasive grain the particle size of whose is 12.7 micrometers or less, for example, 8.47 micrometers, is used. Moreover, the diameter of a nozzle is usually about phi7mm, and sets up the number of nozzles according to the size and processing speed of a substrate to process.
[0034] Next, as about two 3 - 4 kg/cm and an injection distance, it is set as about 8cm as an injection pressure like the 1st sandblasting processing. The speed of the base for processing is set as 25 mm/min 90 degrees, and the degree of spray angle sets the injection quantity as about 50 g/min.
[0035] By performing such processing, as shown in above-mentioned drawing 1 , an average level difference can obtain further the comparatively smooth substrate 1 for solar batteries in which the irregularity of 0.5 micrometers or less was formed on the irregularity-like front face whose average level difference is about 3 micrometers. ≈ 3,000 nm
[0036] In addition, you may make it inject the liquid which it replaced [liquid] with the abrasive grain and distributed the abrasive grain as a gestalt of other operations of this invention.
[0037] Next, how to manufacture the thin film solar cell 11 shown in drawing 3 using the substrate 1 for solar batteries manufactured as mentioned above is explained.
[0038] First, it manufactured as mentioned above, for example, the substrate 1 for solar batteries with a thickness of 1mm is washed. Since powder, such as an alumina, remains in the substrate front face after processing it with sandblasting, this is for removing it.
[0039] As the washing method, ultrasonic cleaning by pure water is performed, for example. Although not limited especially as the washing

method, if it is the substrate which does not have oil dirt in the substrate front face before sandblasting processing, it is good at easy washing.
[0040] Next, the transparent electric conduction film 4 is formed by the sputtering method on a substrate at 1 micrometer in thickness. CVD and a vacuum deposition may be used for the method of forming the transparent electric conduction film 4. Moreover, although the transparent electric conduction film 4 can use ITO, SnO2, ZnO, etc., since it is not desirable on the property of a solar battery to use only ITO, when using this, it needs to coat several 10nm of front faces with SnO2, ZnO, etc. thinly.
[0041] It did not need to say that the usual conditions were sufficient as the conditions which form the transparent electric conduction film 4, and they were made into an elevated temperature, the special formation conditions, for example, 500 degreeC, for forming irregularity, like the conventional example, and irregularity and the repeatability of field resistance are improved. 8 is formed one by one with plasma CVD equipment after formation of the transparent electric conduction film 4 p layer 6 and i layer [of amorphous silicons] 7 and n layers of amorphous silicons of amorphous silicon carbon. [5 or b layer (amorphous silicon carbon composition change layer)] The thickness of each class 5, 6, 7, and 8 is 10nm, 10nm, 300nm, and 30nm, respectively, for example.
[0042] In addition, although p layers of optimal thickness may exist with a concavo-convex size, for example, as for 5, about 15nm is sufficient at about 15 rate of haze (rate on which light was scattered among the transmitted lights of glass), when it is made about 30 rate of haze, it is desirable to set it as about 18-20nm thickness.
[0043] In addition, an example of the formation conditions of each class is shown in a table.
[0044]
[Table 1]

	基板温度 (℃)	パワー (W/cm²)	圧力 (Torr)	ガス流量 (sccm)
p層	170	0.5	0.25	SiH_4:1, H_2:100, B_2H_6:0.01
b層	170	0.05	0.25	SiH_4:32, H_2:30, CH4:32~0
i層	170	0.1	0.12	SiH_4:42, H_2:14
n層	170	0.5	0.25	SiH_4:1, H_2:100, PH_3:0.01

[0045] Next, 50nm of ZnO(s) is formed by sputtering as a rear-face electrode 9, for example. Finally 500nm of Ag is formed as a rear-face metallic-reflection electrode 10, for example. Thus, as a property of the formed solar battery 11, short-circuit current Isc:19.8 mA/cm2, open-circuit-voltage Voc:0.87V, curvilinear factor FF:0.73, and eta:12.6% of efficiency were acquired. Even if it compares this property with the cell property which performed concavo-convex formation using the conventional transparent electrode, it is equal, and it serves as a large value about the short-circuit current as compared with the case of the 1-time processing by the sandblasting method.
[0046] Thus, although the short-circuit current of a thin film solar cell 11 improves by making the optical path length of the light in the inside of an amorphous silicon film increase, if irregularity is enlarged not much, since the thickness of the **** solar battery 11 is as thin as 0.5 micrometers or less, it will become easy to short-circuit a surface electrode 4 and the rear-face electrode 9. Therefore, it passes under such thickness and about 20% is a concavo-convex limitation at the rate of IZU.
[0047] In the substrate 1 of this invention, since minute irregularity is formed on big irregularity as shown in drawing 1, and the scattering effect of light is produced also with big irregularity as mentioned above, only the minute irregularity of 0.5 micrometers or less can make the rate of haze larger than the case where only minute irregularity with an average level difference of 0.2 micrometers is formed. Furthermore, big irregularity is larger than the thickness of a solar battery 11, and it is irregularity with an average level difference of 3 micrometers or more, and preferably, since dispersion of light is made to increase, a surface electrode 4 and the rear-face electrode 9 several microns or more cannot short-circuit it easily. Since the amorphous silicon film itself accompanies big irregularity and it is formed, this is because the interval of a surface electrode 4 and the rear-face electrode 9 is not shortened.
[0048] Moreover, in order to control film growth conditions by the transparent electrode of SnO2 grade by the conventional method of forming irregularity, it is easy to control delicate irregularity by this invention which forms direct irregularity in a substrate using the sandblasting method to what dispersion in concavo-convex tends to produce by change of slight conditioning.
[0049] Moreover, by the sandblasting method, since irregularity can be formed at a room temperature, it becomes unnecessary not to need an elevated temperature of about 500 degrees C like the conventional ordinary-pressure CVD, but to be able to form irregularity on tempered glass, and to stick the usual glass and usual tempered glass which have not been strengthened like the conventional example by this, and the cost of the part solar cell module can be reduced.
[0050] Furthermore, it is not necessary to thicken for example, in order for a transparent electrode to also enlarge the shape of toothing like the conventional example, the thickness of conventional about 200nm, 1 / 4 - 1/5, is sufficient, and since the part cost of materials can be reduced, low-cost-ization can be attained. [i.e.,]
[0051] Moreover, since irregularity can be formed at a room temperature by the sandblasting method of this invention when using metal substrates, such as a stainless steel substrate, the temperature up of a substrate and a temperature fall do not take time, but the problem of the curvature of a substrate is also lost. Furthermore, in order that the blemish in a metal substrate front face may reduce the yield, although a metal substrate needs to carry out polish processing, by carrying out sandblasting processing of the front face, it can smooth the blemish of the whole substrate, can perform concavo-convex formation simultaneously, and is usually very efficient.
[0052] By using the substrate for solar batteries of such this invention, it also enables efficiency conventionally to form the solar battery more than equivalent by the low cost.
[0053] Although it applies, explains and excels in a glass substrate with the form of above-mentioned operation, of course, you may use the substrate of other materials, such as a stainless steel substrate, as a form of other operations of this invention.
[0054]
[Effect of the Invention] Since according to this invention the scattering effect of light can increase further with the irregularity of a big level difference in addition to the scattering effect of the light by the irregularity of a small level difference since the irregularity of a level difference smaller than it is formed in the front face of an irregularity-like substrate, and the optical path length of the light in the inside of the amorphous silicon film of a solar battery can be made to increase by this as mentioned above, a short-circuit current increases and improvement in the efficiency of a solar battery can be aimed at.

[0055] Moreover, since direct irregularity was formed in the substrate by the sandblasting method, when according to this invention the processing in an elevated temperature becomes unnecessary, and irregularity can be formed on tempered glass like the conventional method of forming an irregular transparent electrode and a metal substrate is used, the problem of the curvature of a substrate will also be solved.
[0056] Moreover, since an abrasive grain with a small particle size is used and sandblasting processing is again performed after the 1st sandblasting processing, it has not been told to a thin film in the case of element manufacture that a crack arises.

[Translation done.]